Journal of Applied Science and Agriculture, 9(4) April 2014, Pages: 1475-1479

AENSI Journals

Journal of Applied Science and Agriculture

ISSN 1816-9112

Journal home page: www.aensiweb.com/jasa/index.html

Investigation Growth and Flowering of *Crocus sativus* Plant Influencing by the Electric Field

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ARTICLE INFO

Article history:
Received 21 January, 2014
Received in Revised form 16 April, 2014
Accepted 22 April 2014
Available Online 5 May, 2014

Keywords:
Electric Field - Germination - Saffron Bulbs - Stem Length.

ABSTRACT

Improved production is an important issue in the fields of agriculture and food production. Therefore, several researchers have tried to develop different methods to overcome the problem of matter and energy crisis. It is well known that electric field can be used to improve seed vigor, growth and maturation of different plant such as; wheat, corn and soybean etc. During the present study, the effect of different intensities of the electric field was evaluated on the growth and flowering of the Crocus sativus. During the present study, seven treatment groups were used and kept separately for 4 (h1) and 8 (h2) hours under three different voltage intensities; V1=3, V2=6 and V3=9 volts. The whole set of experiments was repeated thrice. The control groups were those that had not been kept under the electric field. These treatment groups were studied with the help of the statistical analyses of Split Plot and Randomized Complete Block Design (RCBD). The present results indicate that the effect of electric field was significant on the stigma growth ($p>0.01$) as compared to that of as the growth of saffron-bulb sprouting, petal length, stem length and stigma ($p>0.05$). The highest and lowest germination rate was seen for the treatment group kept under V2h1 and V3h2, respectively. Maximum petal and stem lengths were seen for the treatment group kept under v1h1 conditions. Significantly increased stigma height and weight was associated to V1h2 group and minimum effects of the same parameters were seen in V3h1 treatment group and the minimum flower weight was related to V2h1 treatment group. Maximum and minimal stigma weigh was related to V2h2 and V2h1 treatment group, respectively. The results have shown that the electric field had a positive impact on the growth of Saffron bulbs, petal length, and stem length, stigma and flower weights.

To Cite This Article: Hossein Bari Abarghouei, Investigation Growth and Flowering of Crocus sativus Plant Influencing by the Electric Field, ***J. Appl. Sci. & Agric.,*** *9(4): 1475-1479, 2014*

INTRODUCTION

In recent years, extensive investigations have been carried out to evaluate the effect of electric field on the living organisms. Electric field plays an important role in civilized human life (David Irwin 1939; Baluchi 2004). Nowadays, the electric field is being used to improve different parameters in the fields of agriculture, medicine and industry (Nick Nejad 2007).

Studies on the germination of wheat, Triticale, corn and soybean showed that electromagnetic field can be used as a way to improve seed vigor (Baluchi 2004). Studies have shown that the application of magnetic field, with the intensity of 0.66-1.1 Tesla (T) for 0-120 minutes' intervals, could improve the growth of radish seeds. Electromagnetic field of 0.88 T for 80 minutes could stimulate the germination process of radish (Das 2006; Kerdonfag 2002). While, the low-frequency electric field can also increase the germination rate in corn. Parameters such as; increase in stem height of seedlings, showed that electromagnetic field is effective in increasing plant biomass (Aksyonov 2000).

There are 3 important processes in the plant metabolism that require energy during the plant respiration which are: maintenance of biomass, growth and transport of ions. It is thought that one of these factors affects the absorption rate or respiration rate and this process can be the rate of ion transport, which is influenced by the electric field fluctuations (Pietruszewki 1999; Kiatgamjorn 2002).

During the present study, we have investigated the effect of different intensities of electric field on the growth rate and yield of Crocus Sativus Strain of Saffron plant. Parameters such as; the germination of saffron bulbs, petal length, stem length, stigma weight and flower weight were investigated after the exposure of the plant, during germination and growth processes, to different intensities of electric field.

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MATERIALS AND METHODS

2-1. Study area:

This experiment was conducted in the *Marvast* region of Yazd, Iran. This region is semi-dry with hot weather. Test area was located 180 Km South of Yazd with the longitude of 30 degrees and the latitude of 54 degrees with the height of 1546.6 m above sea level. The average annual temperature of Marvast region is 17 °C, mean annual precipitation is 75 mm and average moisture content is 47%.

2.2 Experimental design and plant species:

Saffron (*C. sativus*) was cultivated in the experimental plots. This plant has bulbs filled with parallel fiber membrane that had already been planted in the area and showed good performance, relatively. During the present study, six treatment groups were studied by applying different voltage intensities (V_1 = 3, V_2 = 6 and V_3 = 9 V) of the electric field to the experimental plants for two 4 (h_1) and 8 (h_2) hours. The experimental groups were named as V_1h_1, V_2h_1, V_3h_1, V_1h_2, V_2h_2, V_3h_2 and the control group. The whole set of experiments was repeated thrice. The control groups were those that had not been kept under the electric field.

2.3. Statistical analyses:

The treatment groups were studied with the help of the statistical analyses of Split Plot and Randomized Complete Block Design (RCBD) and $p > 0.05$ was considered as significant. The experimental design, used in the present study, is shown in Figure 1.

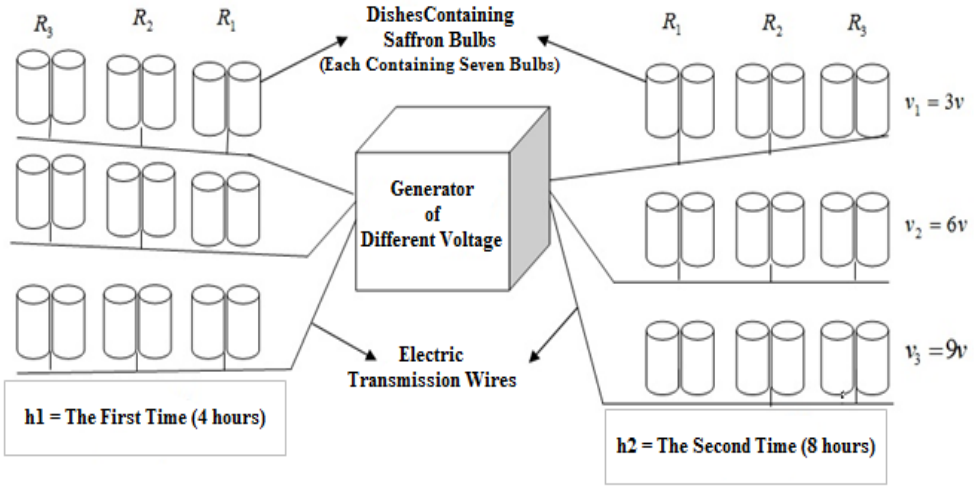

Fig. 1: Schematic diagram of the experimental setup.

3) Results:

The effect of different electric field intensities was significant, during 4 and 8 hours intervals, on the germination of saffron. Most significant effect of the electric field on the saffron germination was seen when the voltage of 6V (V_2) was applied for 8 hours and this experimental group can be simply represented by V_2h_2 group. While, the lowest effect was seen after the application of same field intensity for h_1 (4 hours). Among the six treatment groups, the highest and lowest effect of electric field on saffron germination was seen in V_3h_2 and V_2h_1 treatment groups, respectively. Table 1 show that an increase of the voltage from 3 to 6 V did not cause much difference in germination but the change of voltage from 3 to 9 V show marked improvement in germination process. The effect of electric field was non-significant in h_4 treatment groups as compared to the h_8 ones (Table 1).

Table 1: Analysis of variance (ANOVA) for morphological properties of saffron plant, female buds, petal length and stem length under different voltage intensities of electric field versus time.

Mean Squares (MS)					
Variable sources	df	Germination	Petal length (cm)	stem length (cm)	Stigma length (cm)
Block	2	22.21 **	1.56 ^{ns}	81.73 **	0.097 ^{ns}
Voltage (A)	2	8.20 *	0.013 ^{ns}	0.915 ^{ns}	0.2 ^{ns}
Error of a	4	1.14	0.48335	0.336	0.249
Time level (B)	1	32.55 *	1.31 *	0.624 ^{ns}	0.0052 ^{ns}
Voltage × level time	2	27.81 *	1.59 *	1.74 *	0.33 **
Error of b	6	0.05	0.171	0.216	0.274
Coefficient of variation (%)	-	9.37	17.77	11.4	5.24
ns, ** and * represent Non-significant difference, Significant level of 5% and 1%, respectively.					

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The petal length was significantly affected by the duration of time for which the electric field was applied (4 and 8 hours) also by the interaction between time and voltage. But there was no significant effect of voltage on the petal length. The maximum and minimum petal lengths were seen at 4 and 8 hours, respectively. Maximum and minimum petal lengths, after the application of voltage and time, were observed in V_2h_2 and V_1h_1 treatment groups, respectively. Treatment of saffron plants with the same voltage for 8 hours showed reduced petal length as compared to those treated for 4 hours (Table 1).

The effect of different voltage intensities and time intervals was not significant on the stem length. These results are in contrast to those reported by Safari *et al*. (7) who reported that the maximum and minimum stem lengths, after the treatment of cucumber plants with the voltage during different intervals of time, were observed in V_1h_1 and V_2h_1 treatment groups, respectively (Table 1.).

The effect of different voltage intensities and time was not significant upon the length of saffron stigmas. But the effect of the interaction of voltage and time was significant upon stigma length ($p > 0.01$). The maximum and minimum stigma lengths were seen in V_1h_2 and V_3h_1 treatment groups, respectively (Table 1).

Table 2 shows the effect of different voltage intensities during different time spans on the stigma weights ($p > 0.05$). A decline in the stigma length was seen after the application of saffron plants with electric field for 8 hours as compared to those treated for 4 hours (comparatively increased stigma length; ($p > 0.05$).

Maximum and minimum stigma weights (after their interaction with the parameters of time and voltage) were observed in V_2h_2 and V_2h_1 treatment groups, respectively (Table 2).

Table 2: Analysis of variance for morphological properties of saffron plant, stigma weight, number and weight of flowers under different voltage intensities of electric field versus time.

Mean Squares (MS)				
Variable sources	df	Weight Stigma (gr)	Flower Weight (gr)	Number of Flowers
Repeat	2	0.00003 ^{ns}	0.89 ^{ns}	0.75 ^{ns}
Voltage (A)	2	0.0002 ^{ns}	0.97 ^{ns}	1.00 ^{ns}
Error of a	4	0.00035	0.1385	0.15
Time level (B)	1	0.00065 *	2.26 *	0.30 ^{ns}
Voltage × level time	2	0.00074 *	2.05 *	0.167 ^{ns}
Error of b	6	0.00008 ^{ns}	0.37	0.516
Coefficient of variation (%)	-	9.37	12.38	3.07
ns, ** and * represent Non-significant difference, Significant level of 5% and 1%, respectively.				

Table 2 also demonstrates that different levels of voltage for 4 and 8 hours had significant effects on the flower weights ($p > 0.05$). The maximum and minimum flower weights were recorded after the treatment of saffron plants with V_1 and V_3 for 8 and 4 hours, respectively. In other words, an increase in the voltage from 3 to 9 V could cause a decline in the flower weights.

Effect of time and voltage showed maximum and minimum stigma weights in the V_1h_2 and V_2h_1 treatment groups, respectively. Overall, the present results have shown that the number of flower weight was not affected by the change in voltage, time and the interaction of both (Table 2).

The present study reveals that the voltage intensity of 9 volts (V_3) and the time span of 8 hours (h_2) had significant effects on the overall process of germination in saffron plants. But, the underlying parameters such as the lengths of petals, stem and stigma, and the flower weights were the most affected by the voltage intensity of 3 V (V_1). Fetal and stem lengths were the most significantly affected by the time span of 4 hours while, the stigma length and weight of flowers were more affected by the time span of 8 hours. The stigma weight showed the most significant increase after their application with 6 volts for 8 hours. The number of flowers did not have any change after the application of any intensity of voltage and time (Figure 2).

4) Discussion:

The electric field mostly affects on the transport and metabolism of ions and electrons. Generally, the electric field can affect plant growth in two ways: firstly, it affects on the ions in the soil, and secondly, can have impact on the overall activities of the plants related to the metabolism of electrons and ions (Pozeliene 2000). *Podlesny* et al. (Podlesny 2003) have reported about the significant effect of the electric field on the germination of greenhouse cucumber plants. According to this research group, the effect of the interaction of voltage and time was not significant on the germination of cucumber plant. Electric field can influence the plant metabolism and growth patterns by effecting on the electron transport chain and the dark and light reactions of photosynthesis in leaves (Podlesny 2005; Prokop 2002). Electron transport chain is one of the respiratory pathways in plant tissues, which can be affected by the electric field, which creates changes in the cellular respiration.

Several experiments have shown the significant effects of electric field on the animal cells. For example, electromagnetic field with the intensity of 2 mT and the frequency of 25 Hz could increase the collagen synthesis (Kiatgamjorn 2002).

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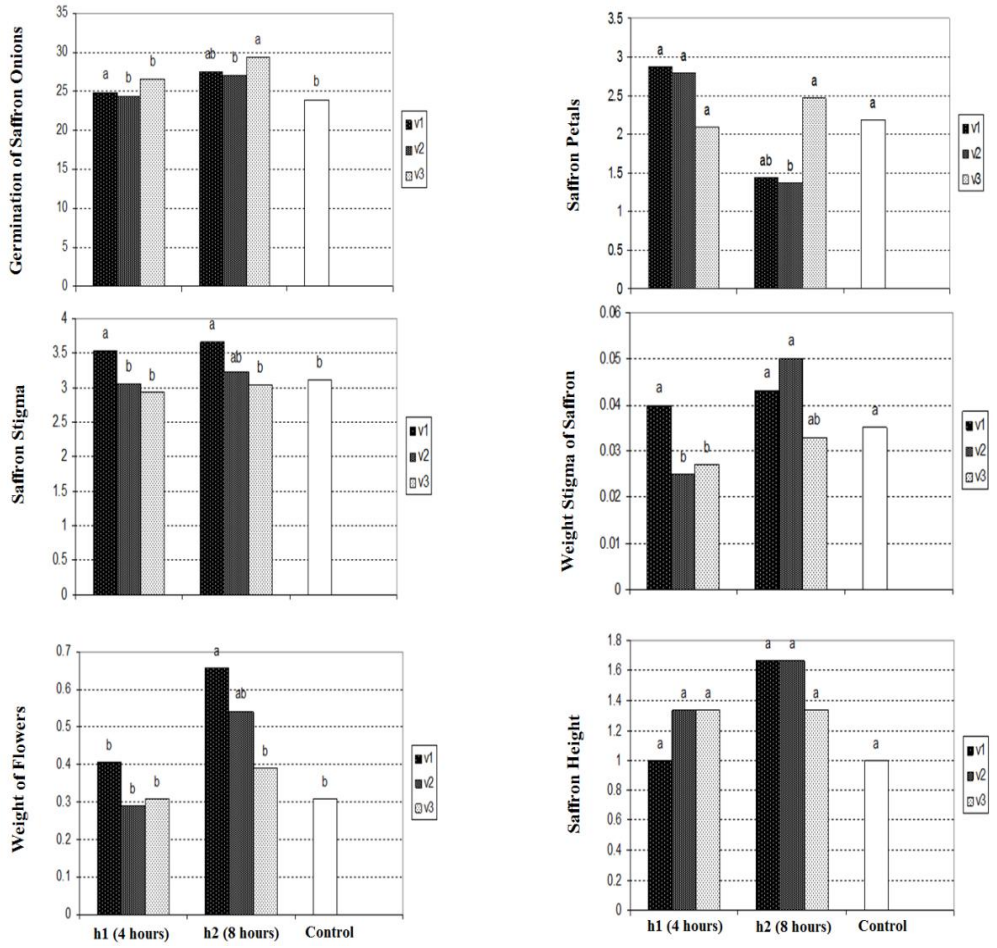

Fig. 2: Effect of different voltage and time parameters of electric field on the plants studied.

According to previous studies, biological treatment of seeds, roots, pollen and buds of some plants could be changed after their exposure to the electromagnetic field (Labes 1993). Electromagnetic field can stimulate seed germination and growth of some crops. This field has a positive effect on the germination and growth of grains, legumes and radish (Pietruszewki 1993; Podlesny 2003; Podlesny2005).

According to a research, the germination of lettuce seeds increased after their exposure to the artificial electrostatic field with the intensity of 75 Vcm^{-1} for 2 minutes (Sidway 1970). While some plants did not show any change in their germination process after with the application of increasing intensities of the electric field (Rochalska 2002). Plant growth depends on the electric field intensity and the duration of exposure of the seeds to electric field (Podlesny 2005). It is assumed that electromagnetic field affects the structure of cell membrane and thereby increases its permeability to different ions and eases their transport across the membrane, which in turn affects the main metabolic activities of plants. The exposure of plant seeds to the electromagnetic field can cause a significant change in the activities of the enzymes that are important in certain stages of germination (Pozeliene 2000).

5) Conclusions:

It can be noted that electric field affects on the movement of ions, electrons and other charged species and causes changes in cell division and growth of the plant. The results of the present study show that the cellular metabolism can be positively affected by the application of appropriate intensity of the electric field. So, a positive effect of 3V intensity of the electric field was seen for some parameters involved in the saffron plant growth and germination while, the administration of 9V electric field could effectively enhance the overall germination process in the saffron plant, which shows that increased crop yield can be achieved by this technique and without using harmful chemical methods.

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ACKNOWLEDGE

The present work was supported by the Research Institute of Science and Nanotechnology, Payame Noor University, Yazd, Iran and the Research and Clinical Center for Infertility, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

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